

(21) Application No: **0409738.2**
 (22) Date of Filing: **30.04.2004**
 (30) Priority Data:
 (31) **60466605** (32) **30.04.2003** (33) **US**

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(51) INT CL⁷:
E21B 23/14 4/18 47/00 , F16L 55/26

(52) UK CL (Edition W):
E1F FHJ FKU
F2P PG1

(56) Documents Cited:
WO 2002/044509 A2 **WO 2001/018351 A1**
WO 2000/073619 A1 **WO 1993/018277 A1**
US 6431270 B1 **US 20020112859 A1**

(58) Field of Search:
UK CL (Edition W) E1F
INT CL⁷ E21B
 Other: **WPI, EPDOC, PAJ**

(64) Abstract Title: **A traction apparatus**

(57) A method and apparatus for performing an operation in a tubular. The method comprising positioning an apparatus in the tubular, the apparatus having a tractor portion 100 and an auxiliary module 150, the tractor moving the apparatus through a tubular and the auxiliary module performing an operation in the tubular. In a further aspect the tractor has a drive member 120 for moving the apparatus in a desired direction, a turbine member adapted to be driven by moving fluid and a conversion member for converting movement of the turbine member to power the drive member 120. The auxiliary module may be for debris removal, measuring characteristics of the tubular, creating images of an interior surface of the tubular, placing components at predetermined locations or taking samples.

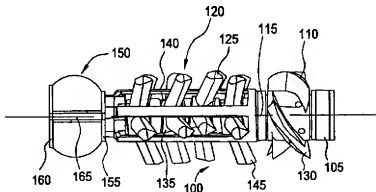


FIG. 1

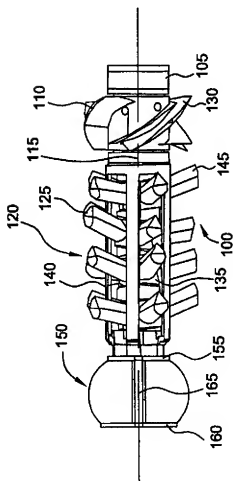


FIG. 1

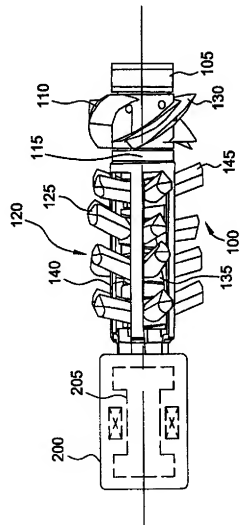


FIG. 2

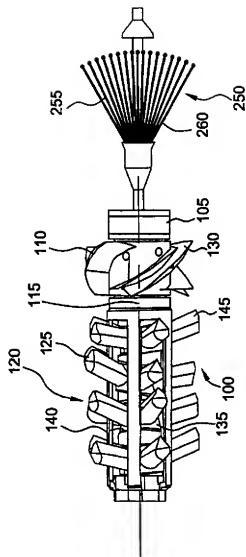


FIG. 3

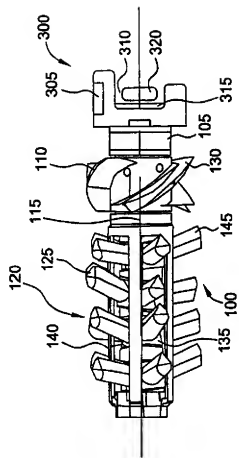


FIG. 4

A TRACTION APPARATUS

Embodiments of the present invention generally relate to completion operation. More particularly, the present invention relates to a method and an apparatus for transporting a tool into a tubular and performing an operation.

The safe and continuous operation of hydrocarbon wellbores and pipeline networks is essential to the operators and users of such networks. Accordingly, such pipeline and wellbores are cleaned and inspected at regular intervals to ensure their operational integrity.

The conventional approach to inspection of operating pipelines is for the tubular string to be precleaned several times using a "dumb" pig. The dumb pig, without any on-board intelligence, typically operates to scrape and remove debris such as wax, scale, sand, and other foreign matter from the tubular. In a newly formed pipeline with a new tubular string, the step of precleaning may not be required. In either case, a detailed inspection is subsequently performed by a "smart" pig, which makes detailed measurements of the tubular string to determine the internal condition of the tubular. The smart pig may also be employed to transport a tool to a predetermined location in the tubular string to perform various operations therein. The smart pig is typically equipped with technologies of varying sophistication. For example, the smart pig may include a mechanism for measuring an interior surface of the tubular string. In another example, the smart pig may include techniques such as magnetic flux leakage (MFL) or

ultrasonic scanning (at various positions along the tubular string) to detect flaws or defects, which might prejudice the tubular's integrity. In other examples, the smart pig may include complex tools generally comprising arrays of probes and sensors for placement of on-line monitoring equipment for later collection or for precise placement of isolation components and radioactive devices.

One shortcoming of conventional pigging inspection operations is that a complicated technique is typically required to position the smart pig at a predetermined location in the tubular string prior to the inspection of the tubular string. For example, one technique requires reversing the flow of fluid in the tubular string to direct the smart pig in the desired direction. This manipulation of the fluid flow may cause numerous problems such as storage problems and production problems. Another technique requires additional components to be constructed adjacent to the tubular string such as a sub-sea pig facility or a second line. These components are used to introduce the smart pig to the predetermined location in the tubular string so that the smart pig can conduct an inspection of the tubular string as it returns to the platform with the flow of fluid in the tubular string. For instance, the second line is constructed adjacent to the tubular string to provide a fluid pathway to pump the smart pig from the platform to the predetermined point in the tubular string. However, these additional components increase the cost of the conventional pigging inspection operation and add undesirable complexity the completion operation.

In a similar manner, a cleaning apparatus or an inspection apparatus may be employed in a wellbore by urging the cleaning apparatus or the inspection apparatus through the wellbore on a string member. However, this technique
5 increases the cost of the wellbore operation.

More recently, an apparatus commonly known as a tractor has been developed that is capable of entering a tubular string at a predetermined point of the tubular string and
10 traveling through the tubular string. The tractor subsequently returns through the same tubular string back to the predetermined point. However, the tractor has not been effectively utilized in conjunction with a pig or other inspection or cleaning tools requiring transportation
15 through a tubular string.

A need therefore exists for a method and apparatus of using a tractor in conjunction with other tools to transport and/or place tools in a pipeline or a wellbore.
20

The present invention generally relates to a method and apparatus for performing an operation in a tubular string. In one aspect, a method comprises positioning an apparatus in the tubular, the apparatus having a tractor portion and
25 an auxiliary module. The method further includes operating the tractor portion to move the apparatus through the tubular and operating the auxiliary module to perform the operation in the tubular.

30 In another aspect, an apparatus for use in a tubular is provided. The apparatus comprises a tractor having a drive member for moving the apparatus in a desired direction, a

turbine member adapted to be driven by moving fluid and a conversion member for converting movement of the turbine member to power the drive member. The apparatus further includes an auxiliary module for use in performing an
5 operation in the tubular.

So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized
10 above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention
15 may admit to other equally effective embodiments.

Figure 1 is a sectional view illustrating a traction apparatus with a wax cutting module in accordance with the present invention.
20

Figure 2 is a sectional view illustrating the traction apparatus with a tubular wall thickness inspection module.

Figure 3 is a sectional view illustrating the traction
25 apparatus with a tubular wall surface inspection module.

Figure 4 is a sectional view illustrating the traction apparatus with a component placement module.

30 In general, the present invention relates to an apparatus for, and method of, performing an operation by utilizing a tractor to transport an auxiliary module into a

tubular. The tractor is an apparatus that is arranged to be driven in the either direction as the fluid in the tubular, but is preferably arranged to be driven in the opposite direction to the fluid flow, that is upstream or against the flow. The tractor is employed for transporting the auxiliary module capable of performing an operation such as detecting a physical condition in the tubular by obtaining data along the entire length of the tubular string, wherein the data is representative of the physical condition. As herein defined, the term "tubular" may refer to a casing for use in a wellbore, a pipe for use in a pipeline or any other type of tubular used in the oil and gas industry. Furthermore, the term "auxiliary module" is defined as any component used to perform an operation in a tubular. To better understand the novelty of the apparatus of the present invention and the methods of use thereof, reference is hereafter made to the accompanying drawings.

Figure 1 is a sectional view illustrating a traction apparatus 100 with a wax cutting module 150 in accordance with the present invention. Herein, the components of the apparatus 100 will be described generally as it relates to the present invention. The components are described in greater detail in U.S. Patent Number 6,722,442, issued to Simpson on April 20, 2004, entitled SUBSURFACE APPARATUS and U.S. Patent Application Publication 2004/0045474, published on March 11, 2004, entitled BI-DIRECTIONAL TRACTION APPARATUS.

The apparatus 100 includes a generally cylindrical body 105 upon which is mounted a rotatable member 110. The rotatable member 110 is typically a turbine rotor having a

number of generally helical blades 130. The rotatable member 110 is operatively attached to a central drive shaft (not shown) via a conversion member 115 such as a gear box. The central drive shaft provides power to a drive member
5 120. Generally, the drive member 120 comprises a plurality of leg members 125.

The leg members 125 each comprise a cam 135 mounted on the drive shaft and six elastomer or compression fingers 145
10 which are oscillated or swashed backwards and forwards by the rotation of the drive shaft. As described in U.S. Pat. No. 6,722,442, the cams 135 are offset to vary the traction provided by each leg member 125 such that rotation of the drive shaft will cause the apparatus 100 to move through a
15 tubular (not shown) contacted by the ends of the fingers 145. The fingers 145 are mounted on the respective cams 135 via bearings 140 and by moving the fingers 145 from one side of the bearing center line to the other it is possible to reverse the direction of traction and to facilitate movement
20 of the apparatus 100 in the opposite direction to the original drive direction.

It is within the scope of the present invention to capture and use the excess power generated by the rotatable
25 member 110 in the apparatus 100 to power the auxiliary module, such as the wax cutting module 150. This may be accomplished by capturing the energy either mechanically, hydraulically, or electrically directly from the conversion member 115. Additionally, the rotation of the drive shaft
30 could be used to rotate a sensor for inspection purposes.

The wax cutting module 150 is adapted to fit at the front end of the apparatus 100 for use in breaking up wax and other deposits from a wall of the tubular. The wax cutting module 150 is operatively attached to the drive shaft through a gear box (not shown) to provide an appropriate rotational speed. Typically, the wax cutting module 150 includes two cutting blades (not shown) mounted within respective rings 155, 160. The wax cutting module 150 also includes a set of axially and radially extending blades 165 between the two rings 155, 160.

In operation, the wax cutting module 150 is rotated and urged through the tubular by the apparatus 100 to break up wax and other deposits on the inner surface of the tubular. Upon dislodging the wax and other deposits such as scale or asphaltene, the deposits are washed past the apparatus 100 and subsequently out of the tubular by flowing fluid in the opposite direction to the directional movement of the apparatus 100. In another embodiment, brush members (not shown) may be attached to an outer surface of several fingers 145. As the apparatus 100 moves through the tubular, the brush members are oscillated or swashed backwards and forwards along with fingers 145 to break up wax and other deposits on the inner surface of the tubular. As set forth above, the deposits are then washed past the apparatus 100 by flowing fluid in the opposite direction to the directional movement of the apparatus 100.

Figure 2 is a sectional view illustrating the traction apparatus 100 with a tubular wall thickness inspection module 200. In a similar manner as set forth above, the

tubular wall thickness inspection module 200 is transported through the tubular attached to the apparatus 100.

The tubular wall thickness inspection module 200 is
5 adapted to fit at the front end of the apparatus 100 for use in measuring the thickness of the tubular using an electromagnetic technique. The result is presented as a type of tubular-inspection log, giving an estimate of metal loss and detecting corrosion. In operation, a coil 205
10 centered inside the tubular generates an alternating magnetic field. Another coil (not shown) measures the phase shift introduced by the tubular. This phase shift depends on the tubular-wall thickness and internal diameter, as well as the tubular conductivity and magnetic permeability. The
15 effects change at different frequencies, so that by varying the frequency, the thickness and internal diameter can be uniquely determined. It should be noted that an array of electromagnetic members may employed with the apparatus 100 without departing from principles of the present invention.
20 An example of a magnet assembly for pipeline inspection equipment is described in GB 1510225 and GB 1535252, both of which are herein incorporated by reference in their entirety. Electromagnetic thickness can also be measured using other techniques such as a tubular-potential profile
25 or a flux-leakage measurement.

In another embodiment, an ultrasonic caliper (not shown) may be employed in the tubular wall thickness inspection module 200. The ultrasonic caliper is a device
30 for measuring the internal diameter of the tubular using high-frequency acoustic signals. In operation, a transducer (not shown) emits a high-frequency pulse that is reflected

by the tubular wall back to the transducer. The diameter is determined from the time of flight of this echo and the fluid acoustic velocity. The transducer is rotated to produce a cross section of the tubular size and full-
5 coverage images of the tubular wall. The measurement has high resolution and is used to detect deformations, the buildup of scale, or metal loss due to corrosion. The amplitude of the echo from the inner tubular surface provides qualitative information on the state of the
10 surface, such as corrosion. Tubular thickness may also be measured simultaneously, either by analysis of the tubular resonance signal or by detecting separately the echoes from the inner and outer tubular surfaces. It should be noted that an array of ultrasonic calipers may employed with the
15 apparatus 100 without departing from principles of the present invention.

Figure 3 is a sectional view illustrating the traction apparatus 100 with a tubular wall surface inspection module
20 250. In a similar manner as set forth above, the surface inspection module 250 is transported through the tubular attached to the apparatus 100.

As illustrated, the wall surface inspection module 250
25 is adapted to fit at a back end of the apparatus 100 for use in measuring the interior surface of the tubular string using a multifinger caliper 255 having a plurality of arms 260. By using a large number of arms 260 or fingers, the caliper 255 can detect small changes in the wall of the
30 tubular. The main purpose of the measurement is to detect deformations, the buildup of scale, or metal loss due to corrosion. In operation, the wall surface inspection module

250 is urged through the tubular by the apparatus 100 to measure the interior surface of the tubular. Upon contact with a deformation in the tubular, the arms 260 move radially and subsequently send a signal to a memory storage unit (not shown) in the surface inspection module 250 for later use in profiling the interior surface of the tubular.

In another embodiment, an inspection camera (not shown) may be employed in the tubular wall surface inspection module 250. The camera is appropriately positioned to take pictures of the interior surface of the tubular as the apparatus 100 moves therethrough. The camera may also be rotated to capture full coverage images of the interior surface of the tubular by operatively attaching the camera to the drive shaft via a gear box (not shown) to provide an appropriate rotational speed.

Figure 4 is a sectional view illustrating the traction apparatus 100 with a component placement module 300. In a similar manner as set forth above, the component placement module 300 is transported through the tubular attached to the apparatus 100.

As illustrated, the component placement module 300 is adapted to fit at a back end of the apparatus 100 for use in the placement of components 320 in the tubular. The components 320 may be used for acquiring data representative of characteristics of contents of the tubular at predetermined locations in the tubular. The components 320 may also be used for acquiring data about the other characteristics of the tubular, such as temperature and pressure. It should be understood, however, that the

component placement module 300 may be located at any position on the apparatus 100, without departing from principles of the present invention.

5 The component placement module 300 typically includes a sensor 305, such as an odometer, for determining the distance traveled by the apparatus 100 in the tubular. The component placement module 300 further includes a chamber 310 for housing the components 320. The chamber 310
10 includes an ejection device 315 for ejecting the components 320 at the predetermined location in the tubular. An example of a method and an apparatus for monitoring conditions in pipelines is described in WO 02/16908, which is herein incorporated by reference in its entirety.

15

 In operation, the component placement module 300 is urged through the tubular by the apparatus 100 to place the components 320 in the tubular. As the apparatus 100 and the component placement module 300 approach a predetermined
20 location in the tubular, the sensor 305 sends a signal to the ejection device 315 to release one of the components 320 from the chamber 310. After the component 320 is placed in the tubular, the apparatus 100 and placement module 300 both travel through the tubular to the next predetermined
25 location and the ejection procedure is repeated until each component 320 is positioned in the tubular. Thereafter, the components 320 collect data for a predetermined period of time and then may be collected to obtain the data or the data is read by an external device (not shown).

30

 In another embodiment, the component placement module 300 and apparatus 100 may be adapted to transport and place

an isolation member (not shown) at a predetermined location in the tubular. The isolation member may be released in a similar manner as discussed above by using the sensor 305 to determine the predetermined location and using the ejection
5 device 315 to release and activate the isolation member. Thereafter, a portion of the tubular is isolated from another portion of the tubular.

In another embodiment, the component placement module
10 300 and apparatus 100 may be adapted to transport and place a member (not shown) having a detectable source of signals, such as a tracker or location tool, at a predetermined location in the tubular. The member typically emits acoustic or radio signals. The member may be released in a
15 similar manner as discussed above by using the sensor 305 to determine the predetermined location and using the ejection device 315 to release and activate the member.

In another embodiment, a sampling module (not shown)
20 may be adapted to fit on the apparatus 100 for sampling product or contaminant, such as water at tubular low points. In a similar manner as set forth above, the sampling module is transported through the tubular attached to the apparatus 100. Preferably, the sampling module includes a timer or a
25 sensor that sends a signal to open the container at a predetermined location in the tubular and then close the container after it fills with product or contaminant. Thereafter, the apparatus 100 returns the sampling module back to the surface of the tubular or to another
30 predetermined location.

CLAIMS

1. A method for performing an operation in a tubular, the method comprising:
 - 5 positioning an apparatus in the tubular, the apparatus having a tractor and an auxiliary module;
operating the tractor to move the apparatus through the tubular; and
operating the auxiliary module to perform the operation
 - 10 in the tubular.
2. The method of claim 1, wherein the tractor includes:
 - 15 a turbine member adapted to be driven by moving fluid;
and
a conversion member for converting movement of the turbine member
to power the drive member.
 - 20
3. The method of claim 1 or claim 2, wherein the auxiliary module is a debris removal module for use in removing debris from an inner diameter of the tubular.
- 25 4. The method of claim 3, further including rotating the debris removal module.
5. The method of claim 4, wherein the debris removal module is a rotatable cutter.
- 30 6. The method of any of claims 3 to 5, further including oscillating the debris removal module.

7. The method of claim 6, wherein the debris removal module is a brush member operatively attached to a drive member of the tractor.

5

8. The method of claim 1 or claim 2, wherein the auxiliary module is a tubular inspection module for use in measuring a characteristic of the tubular.

10 9. The method of claim 8, further including generating an alternating magnetic field from the inspection module and measuring the phase shift to determine the wall thickness.

10 10. The method of claim 8, further including emitting a high frequency pulse from a transducer in the inspection module that is reflected by the tubular back to the transducer to determine the wall thickness.

20 11. The method of any of claims 8 to 10, further including extending a plurality of fingers in the inspection module to determine an interior surface of the tubular.

25 12. The method of any of claims 8 to 11, further including creating images of an interior surface of the tubular by a camera in the inspection module.

13. The method of claim 12, further including rotating the inspection module to capture full coverage images of the interior surface of the tubular.

30

14. The method of claim 1 or claim 2, wherein the auxiliary module is a component placement module for use in placing a component at a predetermined location in the tubular.

5 15. The method of claim 14, further including measuring the distance traveled by the apparatus in the tubular.

16. The method of claim 14 or claim 15, further including acquiring data representative of characteristics of contents
10 of the tubular at the predetermined location by utilizing the component.

17. The method of any of claims 14 to 16, further including isolating a portion of the tubular from another portion of
15 the tubular by activating an isolation member in the component.

18. The method of claim 1 or claim 2, wherein the auxiliary module is a sampling module.
20

19. The method of claim 18, further including activating a sampling mechanism in the sampling module at a predetermined point in the tubular to obtain a sample of fluid.

25 20. An apparatus for use in a tubular, comprising:
a tractor having:

a drive member for moving the apparatus in a desired direction;

a turbine member adapted to be driven by moving
30 fluid;

a conversion member for converting movement of the turbine member to power the drive member; and

an auxiliary module for use in performing an operation in the tubular.

21. The assembly of claim 20, wherein the auxiliary module
5 is a tubular wall thickness inspection module.

22. The assembly of claim 20, wherein the auxiliary module
is a tubular wall surface inspection module.

10 23. The assembly of claim 20, wherein the auxiliary module
is a component placement module.

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Application No: GB0409738.2

Examiner: Gareth Bond

Claims searched: 1 to 23

Date of search: 10 August 2004

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1,8,14	WO02/044509 A2 (Western Well Tool) See figure 1 and page 14 lines 22 to 29.
X	1,2,3, 6,7,20	WO01/18351 A1 (Weatherford/Lamb) See figure 7, page 2 lines 16 to 30 and page 6 line 4 to page 7 line 11.
X	1,2,20	WO00/73619 A1 (Weatherford/Lamb) see figure 2 and page 9 line 7 to page 11 line 2.
X	1,8	WO93/18277 A1 (Hallundback) See figure 1 and page 4 line 16 to page 5 line 3.
X	1,3, 8,14	US2002/0112859 A1 (Bloom et al) See figure 1 and page 8 paragraphs 86 to 89.
X	1,8, 12- 19	US6431270 B1 (Intelligent Inspection Corporation) See figures 1 to 6, column 1 lines 31 to 42 and column 7 line 38 to column 8 line 46.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^W :

E1F

Worldwide search of patent documents classified in the following areas of the IPC^{U7}

E21B

The following online and other databases have been used in the preparation of this search report



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WPI, EPODOC, PAJ